

REMARKS

Claim 55 has been amended. Claims 4, 14 and 38-54 and 56 are canceled. Claims 1-3, 5-13, 15-37, 55, and 56 are pending in this application. Applicant reserves the right to pursue the original claims and other claims in this or other applications.

Claims 1, 4, 11, 15-18, and 56 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,489,643 to Lee (Lee) in view of U.S. Publication No. 2002/0171077 to Chu (Chu) and in further view of U.S. Patent No. 6,117,702 to Nakamura (Nakamura). The rejection is respectfully traversed.

Claim 1 recites a pixel cell for an image sensor, the pixel cell comprising, among other elements “a photodiode for generating charge in response to light and for amplifying the generated charge, the photodiode being formed within a substrate and below an upper surface thereof and comprising at least two of a first layer having a first band gap and at least two of a second layer having a second band gap, wherein the first layers are alternated with the second layers, and wherein the at least two first layers and the at least two second layers are configured to promote ionization by a first carrier type and suppress ionization by a second carrier type in the presence of an electric field” and “a gate of a transistor adjacent to the photodiode for transferring the amplified charge from the photodiode.”

Lee fails to disclose, teach, or suggest the above noted limitations of claim 1. Instead, Lee discloses a pinned photodiode having a plurality of PN junctions to improve the capacitance of the photodiode. Lee is not concerned with amplifying charge or providing “at least two of a first layer having a first band gap and at least two of a second layer having a second band gap, wherein the first layers are alternated with the second layers, and wherein the at least two first layers and the at least two second layers are configured to promote ionization by a first carrier type and suppress ionization by a second carrier type in the presence of an electric field,” as recited by claim 1.

The Office Action points to FIG. 13 of Nakamura as teaching the first and second layers of the claimed photodiode. However, the FIG. 13 photosensitive structure of Nakamura is not part

of a pixel cell and is not “formed within a substrate and below an upper surface thereof,” as recited in claim 1. Moreover, there is nothing in Lee or Nakamura to suggest to one skilled in the art to replace the photodiode of Lee with the photosensitive structure shown in Nakamura’s FIG. 13 to achieve the pixel cell recited by claim 1.

Chu is cited as disclosing “a photodiode and a graded buffer layer beneath a bottom layer of the photodiode” and fails to cure the deficiencies of Lee and Nakamura. For at least these reasons, claim 1 should be allowable.

Claims 4, 11, and 15-18 depend from claim 1 and are allowable along with claim 1, and on their own merits.

For at least these reasons, Applicant respectfully requests the rejection be withdrawn, and the claims allowed.

Claim 19 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Lee in view of Chu, Nakamura and in further view of U.S. Patent No. 6,232,626 to Rhodes (Rhodes). The rejection is respectfully traversed.

Claim 19 depends from claim 1, and is allowable over the Lee and Chu combination for all the reasons presented for claim 1, and on its own merits. Rhodes is cited as disclosing a pixel cell where the substrate is a silicon-on-insulator substrate, and fails to cure the deficiencies of Lee, Chu and Nakamura. For at least these reasons, Applicant respectfully requests the rejection be withdrawn, and the claim allowed.

Claims 2-3, 5-8, 12-13, 20-29 and 32-34 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Lee in view of Chu, Nakamura and in further view of U.S. Patent No. 5,818,322 to Tasumi. The rejection is respectfully traversed.

Claims 2, 3, 5-8, 12, and 13 depend from claim 1 and are allowable along with claim 1, and on their own merits. Tasumi is cited as disclosing the differences between the valence band

energies and the conduction band energies, and does not cure the deficiencies of Lee, Chu and Nakamura.

Claim 20 recites similar limitations to those presented for claim 1. Claim 32 recites an image sensor comprising “a photodiode formed below an upper surface of a substrate, the photodiode comprising at least two layers of Si alternating with at least two layers of $\text{Si}_x\text{Ge}_{1-x}$.” For at least the reasons presented with respect to claim 1, Lee, Chu and Nakamura do not render claims 20 and 32 obvious. As noted above, Tasumi is cited as disclosing the differences between the valence band energies and the conduction band energies, and does not cure the deficiencies of Lee, Chu and Nakamura.

For at least these reasons, Applicant respectfully requests withdrawal of this rejection.

Claims 30, 31, and 35-37 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Lee in view of Chu, Nakamura, Tasumi, and in further view of U.S. Patent No. 6,232,626 to Rhodes.

Claims 30 and 31 depend from claim 20 and are allowable for all the reasons presented for claim 20, and on their own merits. For claim 30, Rhodes is cited as disclosing readout circuitry connected to a floating diffusion region for reading out charge, and fails to cure the deficiencies of the other references. For claim 31, Rhodes is cited as disclosing circuitry peripheral to the array, the peripheral circuitry being at a surface of the substrate where the substrate is silicon-on-insulator, and fails to cure the deficiencies of the other references.

Claim 35 recites limitations similar to those of claim 20, and is allowable for at least the reasons presented for claim 20, and on its own merits. For claim 35, Rhodes is cited as disclosing a processor system including a processor coupled to the image sensor and with readout circuitry electrically connected to the floating diffusion region, and fails to cure the deficiencies of the other references.

For at least these reasons, Applicant respectfully requests withdrawal of this rejection.

Claim 55 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Lee in view of Nakamura. The rejection is respectfully traversed.

Claim 55 recites a pixel cell for an image sensor, the pixel cell comprising “a photodiode for generating charge in response to light and for amplifying the generated charge, the photodiode being formed within a trench in a substrate and comprising at least two of a first layer having a first band gap and at least two of a second layer having a second band gap, wherein the first layers are alternated with the second layers, and wherein the at least two first layers and the at least two second layers are configured to promote ionization by a first carrier type and suppress ionization by a second carrier type in the presence of an electric field.”

Neither Lee nor Nakamura teach or suggest all limitations of independent claim 55. Specifically, Lee and Nakamura are silent about “the photodiode being formed within a trench in a substrate,” as recited by claim 55. Lee’s photodiode is below a surface of the substrate but is part of the substrate. Lee, FIG. 7. Nakamura’s photo detector is formed over a substrate. See e.g., Nakamura, FIGS. 1A, 8A and 10. For at least these reasons, Applicant respectfully requests that this rejection be withdrawn.

In view of the above amendment, Applicant believes the pending application is in condition for allowance.

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Respectfully submitted,

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